ME-833: Computational Fluid Dynamics-II (3-0)

Objectives

1. Introduction to turbulence: provide an insight into the nature of turbulent flows.
2. Basics concepts in turbulence theory: develop an understanding of turbulent scales, energy cascade, the Kolmogorov hypothesis.
3. Flow physics of turbulence flows: provide an overview of basic physics of turbulent flows for a range of applications.
4. DNS and LES: establish an understanding of Direct numerical simulation (DNS) and Large eddy simulation (LES) with their assumptions and limitations and different statistical tools to characterise turbulence.
5. Turbulence modelling: provide an insight into the different types of turbulence modelsused with their limitations and assumptions.

Contents

1. Introduction to turbulence: An insight into the nature of turbulent flows.
2. The scales of turbulent motions: Energy cascade, the Kolmogorov hypothesis.
3. The equations of fluid motion: non-dimensionlisation of Navier-Stokes equations, spatial and temporal descretisation (Incompressible flows). An introduction to Cartesian tensors notations.
4. Wall flows; Channel flows, pipe flows, Boundary layers, near-wall turbulent structures.
5. Direct numerical simulation: Overview, different types of Fractional step method (FSM), Poisson equation solution.
6. Large eddy simulation: Overview, sub-grid scale (SGS) modelling, different SGS models.
7. Turbulent statistics: RMS fluctuations, boundary layer thickness, displacement thickness, momentum thickness, RMS vorticity, turbulent kinetic energy budgets, probability density function (pdf), anisotropy tensor.
8. Turbulence modelling: turbulent viscosity hypothesis; closure problem, overview of major turbulence models: the mixing length model, the k − model, the k − ω model, the Sparlart-Allmaras model.

Reading material

1. S. B. Pope: Turbulent Flows. Cambridge University Press, 2003.
2. P A Davidson: Turbulence. An Introduction for Scientists and Engineers, Cambridge University Press, 2004.
3. J Mathieu & J Scott: An Introduction to Turbulent Flow, Cambridge University Press, 2000.
4. H Tennekes & J L Lumley: A First Course in Turbulence, MIT, 1972.
5. U Frisch: Turbulence, Cambridge University Press, 1995.
6. D. C. Wilcox: Turbulence Modeling for CFD, 1st edition, DCW Industries Inc., La Canada CA, 1993.